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Title of the Invention: ELECTROPHORETIC RECORDING MEMBER
AND ELECTROPHORETIC DISPLAY DEVICE

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[Claims]

[Claim 1] An electrophoretic recording medium, comprising:

an anisotropically conductive electrode being conductive in a thickness direction thereof and not conductive in a vertical width direction and a lateral width direction thereof;

a counter electrode opposing the anisotropically conductive electrode with a predetermined gap therebetween, thereby providing a predetermined space between the counter electrode and the anisotropically conductive electrode; and

a dispersion system contained in the space and obtained by dispersing a plurality of electrophoretic particles in a dispersion medium, wherein

an image is displayed by an electric field according to an image signal applied between the anisotropically conductive electrode and the counter electrode, and the image is retained after the electric field is removed.

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[Claim 2] An electrophoretic recording medium according to claim 1, wherein the counter electrode is one of a planar electrode, a plurality of vertical linear electrodes, a plurality of lateral linear electrodes and a group of electrodes arranged in a matrix.

[Claim 3] An electrophoretic recording medium according to claim 1, wherein at least one of the anisotropically conductive electrode and the counter electrode is a transparent electrode.

[Claim 4] An electrophoretic recording medium according to claim 1, wherein the counter electrode is an anisotropically conductive electrode being conductive in a thickness direction thereof and not conductive in a vertical width direction and a lateral width direction thereof.

[Claim 5] An electrophoretic recording medium according to claim 1 or 4, wherein the anisotropically conductive electrode is a transparent electrode obtained by dispersing a plurality of conductive transparent particles in a transparent resin, and the transparent resin and the plurality of conductive transparent particles have substantially the same refractive index.

[Claim 6] An electrophoretic display device, comprising: an electrophoretic recording medium comprising an anisotropically conductive electrode being conductive in a thickness direction thereof and not conductive in a vertical width direction and a lateral width direction thereof, a counter electrode opposing the anisotropically conductive electrode with a predetermined gap

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therebetween, thereby providing a predetermined space between the counter electrode and the anisotropically conductive electrode, and a dispersion system contained in the space and obtained by dispersing a plurality of electrophoretic particles in a dispersion medium, wherein an image is displayed by an electric field according to an image signal applied between the anisotropically conductive electrode and the counter electrode, and the image is retained after the electric field is removed; and a driver removably assembled with the electrophoretic recording medium, the driver comprising a driving electrode which is in contact with the anisotropically conductive electrode when the electrophoretic recording medium is attached, and application means for applying, via the driving electrode, the electric field according to the image signal between the anisotropically conductive electrode and the counter electrode.

[Claim 7] An electrophoretic display device according to claim 6, wherein the counter electrode and the driving electrode comprise a combination of a planar electrode and a group of electrodes arranged in a matrix or a combination of a plurality of vertical or lateral linear electrodes and a plurality of lateral or vertical linear electrodes.

[Claim 8] An electrophoretic display device according to claim 6, wherein at least either the anisotropically conductive electrode and the driving electrode or the counter electrode is(are) a transparent electrode(s).

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[Claim 9] An electrophoretic display device according to claim 6, wherein:

the counter electrode is an anisotropically conductive electrode being conductive in a thickness direction thereof and not conductive in a vertical width direction and a lateral width direction thereof; and

the driver comprises another driving electrode which is in contact with the counter electrode when the electrophoretic recording medium is attached, with the application means applying the electric field to the counter electrode via the other driving electrode.

[Claim 10] An electrophoretic display device according to claim 9, wherein: the driving electrode and the other driving electrode comprise a combination of a planar electrode and a group of electrodes arranged in a matrix or a combination of a plurality of vertical or lateral linear electrodes and a plurality of lateral or vertical linear electrodes.

[Claim 11] An electrophoretic display device according to claim 9, wherein at least either the anisotropically conductive electrode and the driving electrode ~~on the~~ counter electrode and the other driving electrode are transparent electrodes.

[Claim 12] An electrophoretic display device according to claim 6 or 9, wherein the anisotropically conductive electrode is a transparent electrode obtained by dispersing a plurality of conductive transparent particles in a transparent resin, and the transparent resin and the plurality of conductive transparent particles have substantially the same refractive index.

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[Detailed Description of the Invention]

[0001]

[Field of the Invention] The present invention relates to an electrophoretic recording medium and an electrophoretic display device utilizing an electrophoresis phenomenon and, in particular, to an electrophoretic recording medium and an electrophoretic display device in which an electrophoretic recording medium and a driver can be separated from each other.

[0002]

[Prior Art] The "electrophoresis phenomenon" is based on an electric double layer which is typically produced at an interface between a solid (an electrophoretic particle) and a liquid (a dispersion medium). An electric charge is provided on the surface of the particle according to the combination of materials of the particle and the dispersion medium and the action of a surfactant added to the dispersion medium. The particle migrates in a desired direction at a desired speed using a force applied to the charge on the surface thereof as a driving force.

[0003] A display mode utilizing such an electrophoresis phenomenon is simple in structure and has a wide selection of display colors, high contrast, a wide viewing angle, a low driving voltage, low power consumption and an image memory property, thereby providing various functions which are difficult to achieve with a CRT display or an LCD. For example, it is possible to clearly display images with frequent changes, and to continu-

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ously display a still image based on the image memory property with no supply energy.

[0004] Conventional electrophoretic display devices can be generally classified by the driving mode into: those of a mode where an image signal is directly applied from a pair of electrodes in contact with a dispersion system to the dispersion system (a direct application mode) (e.g., Japanese Patent Laid-Open Publication No. 6-148693); and those of a mode where a dispersion system is provided between an insulative plate and an electrode, and an outer surface of the insulative plate is irradiated with an ion flow by ion flow irradiation means so as to indirectly apply an image signal from outside of the insulative plate to the dispersion system (an indirect application mode) (e.g., Japanese Patent Laid-Open Publication No. 61-86780, Japanese Patent Laid-Open Publication No. 6-202168).

[0005] The conventional electrophoretic display device employing the direct application mode can produce a high resolution image with a minimum applied voltage since the ~~electrodes is~~ electrodes are in contact with the dispersion system, while a matrix two-dimensional driving can easily be conducted, thereby being suitable for a high-speed write operation.

[0006] In the conventional electrophoretic display device employing the indirect application mode, the electrophoretic recording medium having the dispersion system is separated from the ion flow irradiation means, so that the electrophoretic recording medium does not need to have a group of electrodes, whereby the electropho-

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retic recording medium is simple and inexpensive. Therefore, a plurality of screens can be viewed at the same time by exchanging only the electrophoretic recording media while using the same ion flow irradiation means, whereby a plurality of screens can easily and inexpensively be produced one after another.

[0007]

[Problems to be Solved by the Invention] However, in the conventional electrophoretic display device employing the direct application mode, the group of electrodes arranged in a matrix are integrated with the electrophoretic recording medium. Therefore, the conventional electrophoretic display device is not significantly different from, e.g., a twisted nematic type liquid crystal display. For example, there was an inconvenience in that in order to view a plurality of screens at the same time, it is necessary to display only parts of screens using the maximum number of pixels which can be used or to provide a plurality of display devices. Thus, other than utilizing the memory property for the sake of a driving operation, e.g., rewriting only a changed portion of an image, thereby suppressing a flicker on the screen, and reducing the power consumption, the memory property was only utilized to retain the written image unchanged for a certain period of time, during which the driver, which is a relatively expensive component had to stop operating.

[0008] Moreover, in the conventional electrophoretic display device employing the indirect application mode, it is difficult to arrange an ion source and an ion flow control blade of the ion flow irradiation means in a ma-

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trix two-dimensional arrangement which is required for high-speed write operations, and it is also difficult to instantaneously invert the polarity of the ion irradiation. Thus, such a conventional electrophoretic display device is not suitable for high-speed driving. Moreover, since a signal is applied for driving the dispersion system via the insulative plate, the resolution is likely to deteriorate.

[0009] Therefore, an object of the present invention is to provide an electrophoretic recording medium and an electrophoretic display device which is capable of providing high resolution images at a high speed and allows for comparison among a plurality of still images with a simple and inexpensive structure.

[0010]

[Means for Solving the Problems] In order to achieve the object, the present invention provides an electrophoretic recording medium, comprising: an anisotropically conductive electrode being conductive in a thickness direction thereof and not conductive in a vertical width direction and a lateral width direction thereof; a counter electrode opposing the anisotropically conductive electrode with a predetermined gap therebetween, thereby providing a predetermined space between the counter electrode and the anisotropically conductive electrode; and a dispersion system contained in the space and obtained by dispersing a plurality of electrophoretic particles in a dispersion medium, wherein an image is displayed by an electric field according to an image signal applied between the anisotropically conductive electrode and the counter electrode, and the image

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is retained after the electric field is removed. With such a structure, when an electric field according to an image signal is applied between the anisotropically conductive electrode and the counter electrode, the electrophoretic particles migrate in the dispersion medium due to the polarity of the charge on the electrophoretic particles and the polarity of the applied electric field, and the electrophoretic particles gather along the anisotropically conductive electrode or the counter electrode. By using a color for the electrophoretic particles which is different from the color used for the dispersion medium, images are visually displayed. By providing the counter electrode of the recording medium as an electrode which covers the entire surface or an anisotropically conductive electrode which also functions as a substrate, the recording medium can be made in a simple and inexpensive structure, thereby providing a simpler and less expensive structure for producing a plurality of still images. Since the anisotropically conductive electrode and the counter electrode are in contact with the dispersion system, a high resolution image can be produced with a minimum applied voltage.

[0011] In order to achieve the above object, the present invention also provides an electrophoretic display device, comprising: an electrophoretic recording medium, comprising an anisotropically conductive electrode being conductive in a thickness direction thereof and not conductive in a vertical width direction and a lateral width direction thereof, a counter electrode opposing the anisotropically conductive electrode with a predetermined gap therebetween, thereby providing a predetermined space between the counter electrode and the ani-

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sotropically conductive electrode, and a dispersion system contained in the space and obtained by dispersing a plurality of electrophoretic particles in a dispersion medium, wherein an image is displayed by an electric field according to an image signal applied between the anisotropically conductive electrode and the counter electrode, and the image is retained after the electric field is removed; and a driver removably assembled with the electrophoretic recording medium, the driver comprising a driving electrode which is in contact with the anisotropically conductive electrode when the electrophoretic recording medium is attached, and application means for applying, via the driving electrode, the electric field according to the image signal between the anisotropically conductive electrode and the counter electrode. With such a structure, when the electrophoretic recording medium is attached to the driver so that the anisotropically conductive electrode of the electrophoretic recording medium contacts the driving electrode of the driver, the anisotropically conductive electrode and the driving electrode are switched to a conductive state. In this state, when the application means applies an electric field according to an image signal between the anisotropically conductive electrode and the counter electrode via the driving electrode, the electrophoretic particles migrate in the dispersion medium due to the polarity of the charge on the electrophoretic particles and the polarity of the applied electric field, and the electrophoretic particles gather along the anisotropically conductive electrode or the counter electrode. Moreover, it is possible to continuously display the image after the electric field applied to the dispersion system is removed, whereby a plurality of still images

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can be compared by exchanging only the electrophoretic recording media while using the same driver, whereby a plurality of still images can be produced one after another. When the electrophoretic recording medium can be separated from the driver, a plurality of still images to be compared with one another can be produced with a simple and inexpensive structure comprising a single driver and a plurality of recording media, rather than using a plurality of display devices each including a recording medium. By employing a combination of a planar electrode and a group of electrodes arranged in a matrix or a combination of a plurality of vertical or lateral linear electrodes and a plurality of lateral or vertical linear electrodes, as an electrode combination for applying an electric field to the dispersion system, it is possible to conduct matrix two-dimensional driving, thereby writing images to the recording medium at a high speed. Thus, the present invention takes advantage of the conventional direct application mode, such as the high resolution property and the high speed property, and takes advantage of the conventional indirect application mode, such as the simplicity of the recording medium and the image comparison capability, while solving the problems associated with these modes.

[0012]

[Embodiments of the Invention] Hereinafter, embodiments of the present invention will be described in detail with reference to the figures. Figure 1 is a cross-sectional view illustrating a structure of an electrophoretic recording medium according to the first embodiment of the invention.

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[0013] The electrophoretic recording medium (hereinafter, referred to simply as the "recording medium") 1A comprises: a display side substrate 11 and a non-display side substrate 12, as an anisotropically conductive electrode, held together via a spacer 10; a planar electrode 13 as a counter electrode provided on an inner surface 11a of the display side substrate 11; a dispersion system 16 contained between the substrates 11 and 12, the dispersion system 16 comprising a dispersion medium 14 and a plurality of electrophoretic particles 15; and a connector 17 connected to the planar electrode 13.

[0014] The spacer 10 is made of, for example, a polyester film, or the like, and is provided at the end of the substrates 11 and 12 and, as necessary, in the dispersion system 16.

[0015] The display side substrate 11 is made of, for example, a transparent glass, plastic, or the like.

[0016] Figure 2 is a plan view illustrating an important part of the non-display-side-substrate 12. The non-display side substrate 12 is obtained by dispersing a plurality of conductive particles 12b in a film 12a, as illustrated in Figure 2. An area where the conductive particles 12b are present has an anisotropic conductivity such that it is conductive in the thickness direction thereof due to the conduction effect thereof and not conductive in the vertical width direction and the lateral width direction. As the non-display side substrate 12 is provided on the non-display side, any of various resins can be used for the film 12a, and any of

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various particles such as nickel particles, carbon particles, glass or plastic particles whose surface has been processed to be conductive.

[0017] The planar electrode 13 is made of an optically transmissive and electrically conductive thin film such as an iridium tin oxide (ITO).

[0018] The dispersion medium 14 may be an insulative organic solvent, such as an isoparaffin-type hydrocarbon, hexylbenzene, tetrafluorodibromoethane, perfluoropolyether or toluenetrifluoride, mixed with a blue dye and an ionic surfactant.

[0019] The electrophoretic particles 15 may be particles obtained by dispersing a white pigment (e.g., TiO_2) in a transparent wax, and may have a diameter of several μm , for example.

[0020] Figure 3 is a cross-sectional view illustrating a structure of the electrophoretic display device according to the first embodiment of the invention to which the recording medium 1A illustrated in Figure 1 is applied. The electrophoretic display device (hereinafter, referred to simply as the "display device") 100A comprises the recording medium 1A illustrated in Figure 1 and a driver 2A for driving the recording medium 1A to conduct a display based on the electrophoretic phenomenon, wherein the recording medium 1A and the driver 2A can be separated from each other.

[0021] The driver 2A comprises: a non-display side substrate 20; a group of electrodes 21 arranged in a matrix

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provided as driving electrodes which contact the non-display side substrate 12 of the recording medium 1A when the recording medium 1A is attached; a grounded connector which is connected to the connector 17 of the recording medium 1A; and a power supply circuit 23 for applying a DC voltage between the group of electrodes 21 and the planar electrode 13 of the recording medium 1A.

[0022] The group of electrodes 21 are provided in a matrix via an insulative region 21a, and are driven by thin film transistors.

[0023] The power supply circuit 23 applies a DC voltage (an electric field) according to an input signal S to the group of electrodes 21 via a lead 23a.

[0024] Next, an operation of the present display device 100A will be described with reference to Figures 4 and 5. Figures 4 and 5 are cross-sectional views illustrating a display state of the recording medium 1A of the present display device 100A. It is assumed herein that the electrophoretic particles 15 are negatively charged and floating in the dispersion medium 14, as illustrated in Figure 1.

[0025] An operator attaches the recording medium 1A illustrated in Figure 1 to the driver 2A, as illustrated in Figure 3. In particular, the non-display side substrate 12 of the recording medium 1A is placed into contact with the group of electrodes 21 of the driver 2A so as to connect the connector 17 of the recording medium 1A with the connector 22 of the driver 2. By placing the non-display side substrate 12 into contact with

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the group of electrodes 21, the non-display side substrate 12 and the group of electrodes 21 will be conductive due to the anisotropic conductivity of the non-display side substrate 12.

[0026] In this state, when the image signal S is externally input, the power supply circuit 23 applies to the group of electrodes 21 a DC voltage (an electric field) of a positive or negative polarity according to the image signal S. Then, as illustrated in Figure 4, the electrophoretic particles 15 located between the group of electrodes 21, to which a negative DC voltage is applied, and the planar electrode 13 migrate in the dispersion medium 14 to gather along the planar electrode 13, whereas the electrophoretic particles 15 located between the group of electrodes 21, to which a positive DC voltage is applied, and the planar electrode 13 migrate in the dispersion medium 14 to gather along the group of electrodes 21.

[0027] From outside of the display side substrate 11, the color of the electrophoretic particles 15 (white in ~~this embodiment~~) is seen in regions (pixels) where the electrophoretic particles 15 have gathered on the side of the planar electrode 13, while the color of the dispersion medium 14 (blue in this embodiment) is seen in regions (pixels) where the electrophoretic particles 15 have not gathered. Thus, images consisting of two colors, i.e., white and blue, are visually displayed on the side of the display side substrate 11. Due to the image memory property, it is possible with no power supply to continuously display a still image on the side of the display side substrate 11 for a long period of time even

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after the connectors 17 and 22 are disconnected, as illustrated in Figure 5. Therefore, a plurality of still images can be compared with one another by exchanging only the recording media 1A while using the same driver 2A, thereby producing a plurality of still images one after another.

[0028] With the display device 100A having such a structure, image data can be written to the recording medium 1A only by arranging the recording medium 1A in contact with the non-display side substrate 20 of the driver 2A in which the group of electrodes 21 are provided and by connecting the connectors 17 and 22, thereby applying an electric field in a pattern according to the image signal to the recording medium 1A. Moreover, it is possible to continuously display the image after the electric field applied to the dispersion system 16 is removed. Therefore, by providing the recording medium 1A so that it can be separated from the driver 2A, it is possible to produce a plurality of still images to be compared to one another with a simple and inexpensive structure comprising a single driver 2 and a plurality of ~~recording media~~ recording media 1A, rather than using a plurality of display devices each including a recording medium. Moreover, since the recording medium 1A does not have a group of electrodes arranged in a matrix or a plurality of vertical or lateral linear electrodes, the recording medium 1A has a simple and inexpensive structure, thereby providing a simpler and less expensive structure for producing a plurality of still images. Furthermore, since the non-display side substrate 12 and the planar electrode 13 are in contact with dispersion system 16, a recording voltage is directly transferred

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to the interface with respect to the dispersion medium 14 while maintaining the resolution of the group of electrodes 21 due to the conductive particles 12b being in contact with the group of electrodes 21, whereby it is possible to produce a high resolution image with a minimum applied voltage. Moreover, since a combination of the planar electrode 13 and the group of electrodes 21 arranged in a matrix is employed as the electrode combination for applying an electric field to the dispersion system 16, it is possible to conduct matrix two-dimensional driving and thus to write an image to the recording medium 1A at a high speed.

[0029] Figure 6 is a cross-sectional view illustrating a structure of an electrophoretic recording medium according to the second embodiment of the present invention. In the figure, the elements having the same functions as those of the recording medium 1A of Figure 1 are denoted by the same reference numerals and will not further be described. The recording medium 1B comprises: a display side substrate 18, as a counter electrode, and a non-display side substrate 12, as an anisotropically conductive electrode, held together ~~via a~~ spacer 10; and the dispersion system 16 comprising the dispersion medium 14 and a plurality of the electrophoretic particles 15 contained between the substrates 18 and 12.

[0030] As the non-display side substrate 12, the display side substrate 18 is obtained by dispersing a plurality of conductive particles 18b in a film 18a. An area where the conductive particles 18b are present has an anisotropic conductivity so that it is conductive in the thickness direction of the substrate 18 due to the

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conduction effect. As the display side substrate 18 is provided on the display side, a transparent resin can be used for the film 18a, and the conductive particles 18b may be particles obtained by forming a transparent conductive film of, for example, an indium oxide, on the surface of a transparent particle of a glass, plastic, or the like. In such a case, it is preferable for preventing images from being skewed that the transparent film 18a and the transparent conductive particles 18b have substantially the same refractive index.

[0031] Figure 7 is a cross-sectional view illustrating a structure of an electrophoretic display device according to the second embodiment of the present invention to which the recording medium 1B illustrated in Figure 6 is applied. In the figure, the elements having the same functions as those of the display device 100A of Figure 3 are denoted by the same reference numerals and will not further be described. The display device 100B comprises the recording medium 1B illustrated in Figure 6 and a driver 2B for driving the recording medium 1B to conduct a display based on the electrophoretic phenomenon, wherein the recording medium 1B and the driver 2B can be separated from each other.

[0032] The driver 2B comprises: a pair of substrates containing a display side substrate 24 and non-display side substrate 20; a plurality of vertical linear electrodes 25 and a plurality of lateral linear electrodes 26 provided respectively on opposing surfaces 24a and 20a of the pair of substrates containing the display side substrate 24 and non-display side substrate 20 for serving as driving electrodes in contact with the dis-

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play side substrate 18 and the non-display side substrate 12 of the recording medium 1B when the recording medium 1B is attached; and a power supply circuit 27 for applying a DC voltage between the electrodes 25 and 26 according to the image signal.

[0033] The plurality of vertical linear electrodes 25 on the display side are provided via an insulative region (not shown), and are made of an optically transmissive and electrically conductive thin film such as an iridium tin oxide (ITO). The vertical linear electrodes 25 are driven by thin film transistors.

[0034] The plurality of lateral linear electrodes 26 on the non-display side are formed via an insulative region 26a, and are driven by thin film transistors.

[0035] The power supply circuit 27 applies a DC voltage (an electric field) according to the input image signal S to the electrodes 25 and 26 via leads 27a and 27b.

[0036] Next, an operation of the display device 100B will be described with reference to Figures 8 and 9. Figures 8 and 9 are cross-sectional views illustrating a display state of the recording medium 1B operated by the display device 100B. It is assumed that the electrophoretic particles 15 are negatively charged and floating in the dispersion medium 14, as illustrated in Figure 6.

[0037] An operator attaches the recording medium 1B illustrated in Figure 6 to the driver 2B, as illustrated in Figure 7. In particular, the display side substrate 18 of the recording medium 1B and the non-display

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side substrate 12 are placed into contact with the plurality of vertical linear electrodes 25 and the plurality of lateral linear electrodes 26, respectively, of the driver 2B. Thus, the display side substrate 18 and the plurality of vertical linear electrodes 25, and the non-display side substrate 12 and the plurality of lateral linear electrodes 26, are switched to a conductive state due to the anisotropic conductivity of the display side substrate 18 and that of the non-display side substrate 12, respectively.

[0038] In this state, when the image signal S is externally input, the power supply circuit 27 applies a DC voltage (an electric field) of the positive or negative polarity according to the image signal S to the vertical linear electrodes 25 and the lateral linear electrodes 26 via the leads 27a and 27b. Then, as illustrated in Figure 8, the electrophoretic particles 15 located between the electrodes 25 and 26 (with a positive DC voltage being applied to the vertical linear electrodes 25 and a negative DC voltage being applied to the lateral linear electrodes 26) migrate in the dispersion medium 14 to gather along the positively charged vertical linear electrodes 25, whereas the electrophoretic particles 15 located between the electrodes 25 and 26 (with a negative DC voltage being applied to the vertical linear electrodes 25 and a positive DC voltage being applied to the lateral linear electrodes 26) migrate in the dispersion medium 14 to gather along the positively charged lateral linear electrodes 26.

[0039] From outside of the display side substrate 18, the color of the electrophoretic particles 15 (white in

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this embodiment) is seen in regions (pixels) where the electrophoretic particles 15 have gathered along the vertical linear electrodes 25, while the color of the dispersion medium 14 (blue in this embodiment) is seen in regions (pixels) where the electrophoretic particles 15 have not gathered. Thus, images consisting of two colors, i.e., white and blue, are visually displayed on the side of the display side substrate 18. Due to the image memory property, it is possible with no power supply to continuously display a still image on the side of the display side substrate 18 for a long period of time even after the connectors 17 and 22 are disconnected, as illustrated in Figure 9. Therefore, a plurality of still images can be compared with one another by exchanging only the recording media 1B while using the same driver 2B, thereby producing a plurality of still images one after another.

[0040] The display device 100B having such a structure according to the second embodiment provides similar effects as those provided by the display device 100A according to the first embodiment. In particular, an electric field in a pattern according to the image signal can be applied to the recording medium 1B, thereby producing a plurality of still images to be compared with one another with a simple and inexpensive structure comprising a single driver 2B and a plurality of recording media 1B. Moreover, since the recording medium 1B does not have a group of electrodes arranged in a matrix or a plurality of vertical or lateral linear electrodes, the recording medium 1B has a simple and inexpensive structure, thereby providing a simpler and less expensive structure for producing a plurality of still images.

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Furthermore, since the non-display side substrate 12 and the display side substrate 18 are in contact with dispersion system 16, a high resolution image can be produced with a minimum applied voltage. Moreover, since a combination of the plurality of vertical linear electrodes 25 and the plurality of lateral linear electrodes 26 is employed as the electrode combination for applying an electric field to the dispersion system 16, it is possible to conduct matrix two-dimensional driving and thus to write an image to the recording medium 1B at a high speed. Furthermore, since the non-display side substrate 12 and the display side substrate 18 are each formed by an anisotropically conductive member having both a substrate function and an electrode function, it is possible to simplify the structure.

[0041] Figure 10 is an outlined perspective view illustrating an electrophoretic display device according to the third embodiment of the present invention. In the display device 100C the substrates 20 and 24 of the driver 2B of the display device 100B according to the second embodiment are coupled to each other with a hinge so that the device can be flipped open, with the power supply circuit 27 being provided inside one of the substrates (the substrate 24 in this example).

[0042] The present invention is not limited to the above-described embodiments, but various other embodiments may be possible. For example, in the first embodiment, the non-display side substrate 12 of the recording medium 1A and the side of the driver 2A facing the non-display side substrate 20 may be transparent so that they can be used as the display side. In such a case,

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the display side substrate 11 and the planar electrode 13 do not have to be transparent. However, if they are transparent, it is possible to display an image on both sides of the device. Moreover, in the first embodiment, the planar electrode 13 may be a plurality of vertical or lateral linear electrodes, and the group of electrodes 21 may be a plurality of lateral or vertical linear electrodes. Alternatively, the planar electrode 13 may be a group of electrodes arranged in a matrix, and the group of electrodes 21 may be a planar electrode. In such a case, transparent electrodes are used for the electrodes provided on the display side. Furthermore, in the second embodiment, the combination of the plurality of vertical linear electrodes 25 and the plurality of lateral linear electrodes 26 may be replaced with a combination of a planar electrode and a group of electrodes arranged in a matrix. In such a case, transparent electrodes are used for the electrodes provided on the display side.

[0043]

[Effect of the Invention] As described above, according to the present invention, the electrophoretic recording medium can be separated from the driver, whereby a plurality of still images to be compared with one another can be produced with a simple and inexpensive structure comprising a single driver and a plurality of recording media, rather than using a plurality of display devices each including a recording medium. It is possible to obtain a plurality of recording media displaying the same or different still images, and the recording media can be arranged in an array on a wall or a board, whereby they can be used for various display applications such

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as various presentations including a presentation at a convention of an academic society. Moreover, since the anisotropically conductive electrode and the counter electrode are in contact with the dispersion medium, a high resolution image can be produced with a minimum applied voltage. Furthermore, when a combination of a planar electrode and a group of electrodes arranged in a matrix, or a combination of a plurality of vertical or lateral linear electrodes and a plurality of lateral or vertical linear electrodes, is employed as the electrode combination for applying an electric field to the dispersion system, it is possible to conduct matrix two-dimensional driving and thus to write an image to the recording medium at a high speed.

[Brief Description of the Drawings]

[Figure 1] A cross-sectional view illustrating a structure of an electrophoretic recording medium according to the first embodiment of the present invention.

[Figure 2] A plan view illustrating an important part of a non-display side substrate according to the present invention.

[Figure 3] A cross-sectional view illustrating a structure of an electrophoretic display device according to the first embodiment of the present invention.

[Figure 4] A cross-sectional view illustrating a display state of the electrophoretic recording medium according to the first embodiment of the present invention.

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[Figure 5] A cross-sectional view illustrating a display state of the electrophoretic recording medium according to the first embodiment of the present invention.

[Figure 6] A cross-sectional view illustrating a structure of an electrophoretic recording medium according to the second embodiment of the present invention.

[Figure 7] A cross-sectional view illustrating a display state of the electrophoretic recording medium according to the second embodiment of the present invention.

[Figure 8] A cross-sectional view illustrating a display state of the electrophoretic recording medium according to the second embodiment.

[Figure 9] A cross-sectional view illustrating a display state of the electrophoretic recording medium according to the second embodiment.

[Figure 10] An outlined perspective view illustrating an electrophoretic display device according to the third embodiment of the present invention.

[Description of the Reference Numerals]

1A, 1B Electrophoretic recording medium

10 Spacer

11, 18 Display side substrate of electrophoretic recording medium

11a Inner surface of display side substrate of electrophoretic recording medium

12 Non-display side substrate of electrophoretic recording medium

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12a, 18a Film
12b, 18b Conductive particle
13 Planar electrode
14 Dispersion medium
15 Electrophoretic particle
16 Dispersion system
17, 22 Connector
20 Non-display side substrate of driver
20a Surface of non-display side substrate of driver
21 Group of electrodes arranged in a matrix
21a Insulative region
23, 27 power supply circuit
24 Display side substrate of driver
24a Surface of display side substrate of driver
25 Vertical linear electrode
26 Lateral linear electrode
26a Insulative region
28 Hinge
100A, 100B, 100C Electrophoretic display device
S Image signal

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[Abstract]

[Problems] To provide an electrophoretic recording medium and an electrophoretic display device capable of producing a high resolution image and allowing for comparison among a plurality of still images with a simple and inexpensive structure.

[Means for Solving the Problems] A recording medium 1A can be separated from a driver 2A, whereby a plurality of still images to be compared with one another can be produced with a simple and inexpensive structure comprising a single driver 2A and a plurality of recording media 1A. Since a non-display side substrate 12 having an anisotropic conductivity in the thickness direction thereof and a planar electrode 13 are in contact with a dispersion system 16, it is possible to produce a high resolution image with a minimum applied voltage. When a combination of a planar electrode and a group of electrodes arranged in a matrix, or a combination of a plurality of vertical or lateral linear electrodes and a plurality of lateral or vertical linear electrodes, is employed as the electrode combination for applying an electric field to the dispersion system 16, it is possible to conduct matrix two-dimensional driving and thus to write an image to the recording medium 2A at a high speed.